INDIA'S METHANE PROBLEM

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Overview

Methane abatement has drawn increased attention in recent years as a key lever for slowing the pace of near-term warming while countries begin to deploy broader decarbonization strategies. This is because methane, though much shorter lived than carbon dioxide (CO_2) in the atmosphere, is far more potent in terms of its immediate climate impact, with 80 times the warming potential of an equivalent mass of CO_2 over a 20-year timeframe. In fact, the International Energy Agency (IEA) estimates that methane, despite being emitted in far smaller quantities than CO_2, has been responsible for about 30% of the overall warming experienced since the Industrial Revolution. Meanwhile, concentrations of methane in the atmosphere have continued to rise, with sharp increases observed in just the last few years.

Methane emissions are difficult to estimate, but based on available national-level data, India is the second largest contributor to global, human-caused methane emissions behind China.[1] India is also particularly vulnerable to the impacts of accelerated warming. But India has yet to join the Global Methane Pledge, a U.S.-E.U. led initiative, announced in 2021 at the 26th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC), that aims to cut global methane emissions 30% by 2030 (compared to 2020 levels). This brief examines the Indian government's reluctance to join the Pledge in the context of the India's overall strategy for addressing climate change, specific methane reduction opportunities in different sectors of the Indian economy, and methane-related initiatives already underway in several Indian states. We conclude that India has a significant opportunity to mitigate potentially devastating near-term climate impacts by embracing a concerted, national-level effort to implement comprehensive, effective methane reduction strategies this decade.

Background and context

Methane (CH_4) is widely recognized as the second most important anthropogenic greenhouse gas (GHG) behind CO_2. According to India's third Biennial Update Report (BUR)[a] to the UNFCCC, national methane emissions in 2016 accounted for approximately 19.5 million tons (Mt) — equivalent to 409 Mt CO_2, using a 100-year global warming potential (GWP) of 21, or 14.43% of India's total GHG emissions.[2] Weighting these emissions by methane's 100-year GWP, however — rather than 20-year GWP — substantially underrepresents their near-term effect on radiative forcing in the atmosphere.

a The last official figure for methane emissions in India are from India's Third Biennial Update Report (2021), which cites data collected in 2016. While estimates vary widely based on prediction models, the International Energy Agency (IEA) estimates that India emitted 30.054 million tonnes of methane in 2023, marking a 1.5-fold increase since 2016.

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In explaining India's reluctance to join the Global Methane Pledge, government officials cite concerns that abatement measures would primarily affect small and marginal farmers in the agricultural sector who are already disproportionately impacted by the sector's relative lack of industrialization.[3] They also point to methane's short 12-year lifetime in the atmosphere to argue that more lasting benefits can be achieved by reducing CO_2 emissions, which have an atmospheric lifetime on the order of hundreds of years. Their view is that focusing on methane under the Pledge "shifts the CO_2 reduction burden to methane reduction."[4]

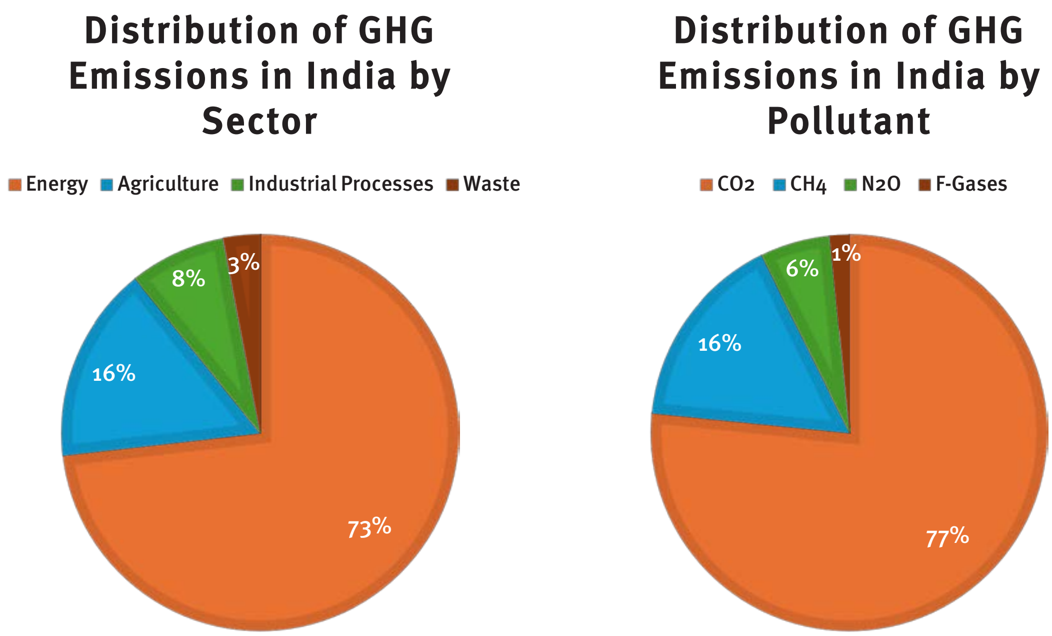

Figure 1: Distribution of GHG emissions, by sector and by gases.[5] *In the figure, contributions from non-CO_2 GHGs are converted to CO_2-equivalent using 100-year GWP. The relative size of the CO_2 share compared to that for CH_4 and N_2O has been cited to support the claim that focusing on methane disproportionately shifts the burden of abatement away from CO_2.*

These rationales, however, discount the near-term warming effects of methane, as reflected in the four-fold difference between methane's 20-year GWP and the (much lower) 100-year GWP used to convert methane to CO_2-equivalent terms for national reporting purposes.[6] This overlooks the fact that reducing methane emissions can provide immediate climate benefits by reducing near-term heat stress, which poses particular threats to India's population and economy.

Indeed, India is considered to be among the countries that are most exposed to damages from climate change. Studies suggest that without rapid action to curb emissions, India will experience increased droughts, rising temperatures, and fluctuating monsoon rainfall. Resulting impacts could be especially severe for India's rain-dependent and resource-scarce agricultural systems and for vulnerable subsistence farmers in particular.[7] It has been estimated, for example, that higher temperatures and lower rainfall could reduce rice yields by 5% and 13% respectively, and wheat yields by 3% and 5% respectively,[8] impacting two of India's largest produced crops.[9]

Accelerated warming over the next decade is also expected to worsen heatwaves, affecting labor productivity and health due to climate-induced diseases and food shortages. A 2019 report from the International Labour Organization estimates that India's workforce could lose 5.8% of working hours by 2030, equivalent to 34 million full-time jobs, due to heat stress.[10] Recognition of these and other impacts undergirds a recent landmark ruling by India's Supreme Court, which holds that citizens are entitled to protection from the adverse effects of climate change under both the Right to Life (Article 21) and Right to Equality (Articles 14–18) provisions of India's Constitution. This ruling, issued in April 2024, substantially expands the government's constitutional obligation to take action against climate change, while also acknowledging the disproportionate impact of warming on India's most vulnerable communities.[11]

Progress toward reducing global methane emissions could be particularly impactful over the next decade because, as the IEA points out, "sharp cuts in methane can deliver a net cooling effect within a relatively short period." India has a range of opportunities across multiple sectors to strengthen existing policies, introduce new regulations, and raise public awareness of methane emissions and climate impacts. State governments, several of which are already leveraging their unique regional expertise to reduce methane emissions, can also be important vehicles for policy implementation and behavioral change.

The remainder of this brief discusses abatement opportunities in the main methane-producing sectors of the Indian economy and describes related initiatives already being undertaken at the local, state, and national levels.

Methane abatement in the context of subnational action plans

In 2009, the Government of India directed all state governments and union territories to prepare *State Action Plans on Climate Change,* consistent with the strategy outlined in the 2008 National Action Plan on Climate Change.[12] While most states have identified methane as an important contributor to climate change, a few — specifically Haryana,[13] Goa,[14] Odisha[15] and Jammu & Kashmir[16] — have also included methane reduction strategies in their state plans for the agriculture sector.[17] Additionally, the states of Kerala,[18] Karnataka,[19] and Rajasthan have identified strategies to address methane emissions from livestock, agriculture, and landfills.[20] A multi-metric evaluation shows that implementing national policies consistent with state-specific targets could generate emissions reductions of 100–1,800 Mt CO_2-equivalent per year across all short-lived climate pollutants (SLCPs), including methane.[21]

Aligning national policies and state-level methane reduction strategies is crucial for enhancing India's overall emissions reduction potential and addressing the most important methane-emitting sectors of the Indian economy, including agriculture, energy, and waste.

Methane reduction opportunities by sector

Agriculture

Agricultural practices in the country have the highest share of methane emissions, with the largest contributions coming from livestock (enteric fermentation) and rice cultivation.[22] Enteric fermentation accounts for roughly 55% of GHG emissions from India's agriculture sector, with an additional 17% and 7% coming from rice cultivation and manure management, respectively. Soil degradation and field burning make up the remainder of estimated sectoral GHG emissions, but these sources are not directly linked to methane production.[23]

Primarily in Punjab, Haryana, and Uttar Pradesh, the Green Revolution of earlier decades has led to water-intensive rice paddy cultivation, increasing methane emissions. To combat this, the Indian government allocated INR 132.8 million (roughly USD 1.5 million) in 2019–20 alone through its Crop Diversification Programme to promote alternative crops, improve soil quality and reduce pests,[24] and has succeeded in diversifying more than 81,816 hectares since 2017. Similarly, the Indian Council of

Agriculture Research has developed two technologies to mitigate methane emissions from rice. System for Rice Intensification (SRI) has the potential to enhance rice yields by 36%–49% while using up to 35% less water compared to traditional rice cultivation, while Direct Seeded Rice (DSR), avoids the need for nurseries or puddling, therefore reducing standing water[25] and cutting methane emissions between 30% and 98%.[26] The state of Haryana has reported converting more than 311,000 acres of paddy fields to DSR,[27] while independent studies in the states of Tamil Nadu, Odisha, and New Delhi have shown methane reductions ranging from 28% to 75% in different rice fields following the adoption of new irrigation methods.[28] However, no pan-India study has been conducted to measure the adoption of the CDP, SRI, or DSR to assess reductions in methane and nitrous oxide (N_2O) emissions.[29]

Another initiative, the Ration Balancing Programme (RBP), aims to address GHG contributions from livestock by educating milk producers to diversify cattle feed away from paddy field byproducts to a wider range of fruits, vegetables, flowers, spices, and nuts. These feed sources are not only more efficient at sequestering carbon below ground during cultivation, but also reduce methane emissions from enteric fermentation in dairy cattle and improve milk production.[30] A pilot project showed that balanced feeding could reduce average methane emissions from cattle by 12.4%,[31] translating to a national methane reduction potential of roughly 1.4 Mt if applied to all dairy cattle in India.[32]

Energy

India's energy consumption has grown seven-fold in the last four decades, with coal now providing 55% of the country's energy needs.[33] A 2018 study found that the energy sector's share of methane emissions had increased to 13%.[34] As a result of new energy regulations, coal mine methane (CMM), released during the mining process, and coalbed methane (CBM), extracted directly from unmined coal seams, have become economically viable sources of natural gas in India.[35] This has led to an increase in emissions from surface mining, which grew by 7% over the period from 2014 to 2016.[36] India's CBM resources are estimated to total 91.8 trillion cubic feet, spread over 11 states;[37] these resources were divided into 33 "blocks" and made available for energy exploration and production via a competitive bidding process starting in 2001. As of 2023, 12 CBM blocks were active, of which 5 had moved beyond the exploration and development phases and have so far produced 6.13 billion cubic meters of methane since production started, with annual production projected to reach 844 million cubic meters by fiscal year 2023–2024.[38]

With appropriate processes and equipment, almost all CMM and CBM can be extracted and turned into an alternative energy source without losing methane to the atmosphere. However, India faces technological challenges to achieving optimal extraction for the nearly 480 billion cubic meters of recoverable CBM estimated to be in the 12 blocks.[39] As a result, development of CBM resources is likely to be a source of higher methane emissions in the future.[40]

Alongside capturing methane from coal, India is working to reduce methane emissions from oil and gas infrastructure. The country is also developing alternative, biogenic sources of natural gas through a pair of biogas programs, Galvanising Organic Bio-Agro Resources (GOBARDhan) and the New National Biogas and Organic Manure Programme.[41] Prime Minister Modi's Global Biofuels Alliance (GBA), which was launched on the side-lines of the G20 Summit in New Delhi in September 2023, aims to bring together the world's largest consumers and producers of biofuels.[42]

Waste

India's waste sector saw a 224% increase in GHG emissions from 1994 to 2016, due to increased population and industrial activities.[43] According to the third Biennial Update Report, annual methane emissions from industrial, domestic, and commercial wastewater treatment and discharge, along with solid waste disposal on land, increased to 2.8 million tons.[44] India has adopted various policies that have the potential to affect methane emissions from this sector, including policies related to climate change adaptation and mitigation, universal sanitation coverage, and waste segregation and minimization. Although these policies do not explicitly address methane, they aim to advance goals, such as making urban areas garbage-free,[45] segregating waste at source,[46] and capturing GHGs at landfills, which could directly or indirectly reduce methane emissions.[47]

India's Solid Waste Management Rules, 2016, dictate proper segregation, collection, treatment, and disposal of solid waste in municipal areas; urban agglomerates; areas under the control of India's railway, airport, and port authorities; and places of religious and historical importance. The rules explicitly state that concentrations of methane gas at landfills cannot exceed 25% of the lower explosive limit.[48] However, Indian cities are still struggling to comply with these rules. Limited public knowledge of waste segregation and open, unmonitored garbage dumps are impeding segregation at source.[49] Additionally, urban local bodies have not been adequately monitoring methane fluxes from existing landfills, fugitive gas emissions, or methane leaks at treatment plants.[50] Limited budgets are a large part of the problem, since municipalities often lack the resources to implement waste management services in a proper manner.[51]

In October 2021, India's national government launched the Swachh Bharat Mission (Clean India Mission) 2.0, a set of guidelines, policies, and initiatives aimed at eliminating open defecation and improving solid waste management.[52] Over the last three years, this initiative has succeeded in converting 901 dumpsites (of 2,438) to green spaces and urban renewal projects, thereby reclaiming more than 4,000 acres of land formerly used for dumping (out of a total of 28,862 acres)[53] and remediating 87 million tons of waste (out of a total of 257 million tons).[54] However, an estimated 70%–90% of unsegregated waste still finds its way into non-engineered landfills, where it gives rise to methane emissions.[55] With rapid population growth, and a commensurate increase in waste generation, modeling analyses estimate that GHG emissions from this sector could increase from 20 Mt CO_2e in 2020 to as much as 76 Mt CO_2e by 2030,[56] regardless of landfill conversion.

Other Multilateral Initiatives

Although India has not yet joined the Global Methane Pledge, it has participated in the Global Methane Initiative (GMI), a voluntary partnership of 45 countries, since its inception (including co-chairing the GMI Steering Leadership Committee in 2021).[57] GMI provides technical support to mitigate methane emissions primarily in three sectors: oil and gas, biogas, and coal mines. It also provides a platform for developing methane reduction strategies and creating avenues for technology exchange while addressing political and economic obstacles to project implementation. India's participation in the GMI and other multilateral initiatives is consistent with several of the priorities India listed when it assumed the G20 presidency in December 2022, including priorities related to green development and sustainability.[58] However, India is one of six G20 members who have not signed the Global Methane Pledge.[b]

b According to the IEA's 2022 Global Methane Tracker, 111 countries representing an estimated 45% of global, human-caused methane emissions, had, to that point, joined the Pledge. Other major emitting countries that have not signed include China and Russia. *Source:* https://www.iea.org/reports/global-methane-tracker-2022/the-global-methane-pledge#abstract

In addition, India has undertaken several bilateral initiatives with the United States that directly or indirectly support methane abatement. Under the 2022 Strategic Clean Energy Partnership, the U.S. and India agreed to abate methane emissions from oil and gas operations, including specifically emissions from gas distribution systems in India's cities. This work is to be implemented through the public-private U.S.-India Low Emissions Gas Task Force,[59] which has sought to advance emerging technologies (hydrogen and Carbon Capture, Utilization, and Storage).[60] The two countries plan to establish a public-private Energy Storage Task Force to support expanded deployment of intermittent renewable energy sources, a Hydrogen Task Force to scale and accelerate the deployment of clean hydrogen technologies, and the launch of a U.S.-India New and Emerging Renewable Energy Technologies Action Platform (RETAP).[61] These initiatives, by reducing dependence on coal to meet future energy needs, will also reduce coal-related methane emissions.

A Way Forward

Prompt and efficient adoption of methane reduction policies in the agricultural, energy, and waste sectors would help India and the world reduce the substantial risks it faces from unchecked warming over the next decade and beyond. A multi-faceted approach that includes technology transfer, policy enforcement, and international cooperation will be essential to address the specific abatement challenges that exist in different sectors and enable effective policy implementation in ways that are responsive to key concerns, such as the need to mitigate potential impacts on small and subsistence farmers in India's agriculture sector.

A well-designed national system for trading carbon credits could create powerful incentives for near-term GHG abatement while also spurring investment in the technologies needed to reduce the long-term carbon intensity of the Indian economy.[62] The development of the nation-wide Indian Carbon Market (ICM), an effort being led by India's Ministry of Power and Ministry of Environment, Forest, and Climate Change, should reflect the different impacts of distinct greenhouse gases, including short-lived climate pollutants like methane. As policymakers consider the methodologies that will be used to estimate emission reductions and removals under the ICM, they should consider alternatives to the common practice of benchmarking all climate pollutants to CO_2 using 100-year GWP, an approach that certainly simplifies the accounting process but that also fails to reflect important differences between pollutants. Methane and other SLCPs not only work on different time frames, but some also have stronger regional effects.[63] Putting them in the same basket as CO_2 on the basis of long-term GWP will tend to undervalue the near-term, on-the-ground benefits that could be achieved in India by targeting these types of emissions. An approach that treats climate pollutants separately, by contrast, would inform better target setting and ensure that incentives for abatement under a market system reflect the diverse impacts of different GHGs over space and time.[64]

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About the Program

The Harvard Methane Initiative seeks meaningful and sustained progress in reducing global emissions of this very important greenhouse gas — through research and effective engagement with policymakers and key stakeholders. This Initiative is supported by the Salata Institute for Climate and Sustainability at Harvard University. The Harvard Methane Initiative and other Research Clusters supported by the Salata Institute comprise interdisciplinary teams of researchers from across Harvard’s schools, whose varied expertise is required to address the complexity of the climate-related problems that they seek to solve. Robert N. Stavins, A.J. Meyer Professor of Energy and Economic Development at Harvard Kennedy School, directs the Harvard Methane Initiative. The findings, views, and conclusions in this publication are those of the authors alone.